

On the status of *Pseudomylothris* Neustetter, a supposed endemic butterfly genus from the Uluguru Mountains of Tanzania (Lepidoptera: Pieridae)

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Abstract. The nominal butterfly genus *Pseudomylothris* Neustetter, 1929, is confirmed to be a junior subjective synonym of *Mylothris* Hübner, 1819 (Lepidoptera: Pieridae). The status of its type species, *Mylothris leonora* Krüger, 1928, variously treated as an endemic species to the Uluguru Mountains of Tanzania, an endemic subspecies of *M. crawshayi* Butler, 1896, or a more wide-ranging subspecies of *M. crawshayi*, is discussed. It is concluded that *M. leonora* represents a Tanzanian endemic species belonging to the *M. sagala* species-group, the significance of which is discussed with respect to the endemism and irreplaceability of the Uluguru conservation area. *Mylothris crawshayi* sensu stricto, from Malawi, is demonstrated to be very distinct from *M. leonora*. *Mylothris sagala seminigra* Berger (December 1980) is noted as a homonym and new synonym of *M. sagala seminigra* D'Abrera (September 1980).

Key words: New synonymy, endemism, Eastern Arc Mountains, Africa, biodiversity, taxonomic status, *Mylothris leonora*.

INTRODUCTION

The Uluguru Mountains of Tanzania, situated south of Morogoro town at approximately 7–8° S and 37–38° E, lie close to the centre of the Eastern Arc Mountains, a biodiversity hotspot (Myers *et al.*, 2000). Major efforts are being made to conserve the fauna and flora of the Ulugurus and other Eastern Arc mountains, particularly to prevent further deforestation (e.g. Arc Journal, 2005). In support of protection it is helpful to be able to point to endemic taxa, the presence of which renders an area 'irreplaceable' (Pressey *et al.*, 1993; Margules & Pressey, 2000).

According to Burgess *et al.* (2002), the Ulugurus have over 130 species of endemic plants, while Burgess

et al. (2007) noted as many as 81 endemic or "near-endemic" species of vertebrates. However, if we focus on strictly endemic bird and mammal species, these numbers do not look quite so impressive. According to Hansen (2005: 11), there is just one strictly endemic species of bird (Uluguru Bushshrike, *Malaconotus alius* Friedmann), and supposedly two strictly endemic mammals: the Geata Mouse Shrew, *Myosorex geata* (Allen & Loveridge), and Telford's Shrew, *Crocridura telfordi* Hutterer (Hansen, 2005: 51). But even of these two, *C. telfordi* is also said to occur in the Udzungwa Mountains (Wilson & Reeder, 2005; Mammals of Tanzania, 2011). According to Burgess *et al.* (2007: 216), the total of all full species of vertebrates considered strictly endemic to the Ulugurus is 13 (but this number appears to include *C. telfordi*).

If endemic taxa are very distinct, such as genera or families, a 'premium' can be added (Vane-Wright *et al.*, 1991; Isaac *et al.*, 2007). The genus *Malaconotus* includes 6 species, *Myosorex* 15, while *Crocridura* has well over 150 species. Neustetter (1929) proposed the genus *Pseudomylothris* to receive *Mylothris leonora*, a pierid butterfly that had been described as a new species from the Uluguru Mountains the previous year (Krüger, 1928). Klotz (1933) was unconvinced but, without access to material, tentatively treated

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Pseudomylothris as a subgenus of *Mylothris* Hübner, 1819. However, its separate status was endorsed by George Talbot who, after examining the type material of *leonora*, commented "This genus possibly forms a link between *Mylothris* and [the Indo-Australian genus] *Delias*" (Talbot, 1944: 184).

The restriction of an entire genus to a single mountain block would be unique among African Pieridae and, despite Talbot's view, *Pseudomylothris* is either ignored in recent printed taxonomic catalogues (e.g. Kielland, 1990; d'Abrera, 1997; see also Braby *et al.*, 2006), or treated explicitly as a synonym of *Mylothris* (e.g. Berger, 1980b; Ackery *et al.*, 1995; Braby, 2005a).

Currently, however, *Pseudomylothris* appears as a seemingly valid genus on more than a dozen electronic databases accessible on the 'web' (WWW, 2011). Although online databases do not have 'priority' over printed taxonomic literature, this leads to uncertainty. The purpose of this paper is to examine the taxonomic status of Neustetter's genus and its single included species, to determine to what extent this insect does or does not represent a further significant argument for conservation in the Uluguru.

MYLOTHRIS HÜBNER, 1819

Mylothris Hübner, 1819. Type species by selection of Butler: *Papilio poppea* Cramer, 1777. [See Hemming, 1967: 302.]

Pseudomylothris Neustetter, 1929: 191. Type species: *Mylothris leonora* Krüger, 1928, by original designation and monotypy. Synonymy with *Mylothris* here confirmed.

Mylothris? subgenus *Pseudomylothris* Neustetter: Klots, 1933: 225.

Pseudomylothris Neustetter: Talbot, 1944: 155, 184.

Mylothris Hübner, 1819: Carcasson, 1962: 61; Berger, 1980b: 872; Ackery, Smith & Vane-Wright, 1995: 217; Braby, 2005: 12; Williams, 2010. [*Pseudomylothris* Neustetter cited as a junior subjective synonym.]

WHY SHOULD *PSEUDOMYLOTHRIS* BE REGARDED AS A SUBJECTIVE SYNONYM OF *MYLOTHRIS*?

Together with his short original description, Neustetter (1929) provided a venation diagram showing only nine veins reaching the forewing margin, including two radials. According to Talbot (1944: 184), "The main distinction between *Mylothris* and *Pseudomylothris* is the absence in the latter of vein 10 of the fw., which is also the case in *Delias*." However, in *Delias* Hübner ten veins, including three branches of the radius, reach the forewing margin (e.g. Bascombe *et al.*, 1999: fig. 7.8, pl. 170). Comparison of Neustetter's figure with van Son's (1949: fig. 115, p. 214) diagram for *Mylothris chloris* (Fabricius) indicates that the supposed difference is better referred to, using the Comstock-Needham system, as the loss of

R_2 , or its complete fusion with R_1 (to form R_{1+2}).

Neustetter (1929) not only figured nine forewing veins for *Pseudomylothris*, but confirmed this in his description ("dass die Vorderflügel nur 9 Rippen besitzen"). Such a venation would be unique among the Pierinae, which otherwise all have 10, 11 or 12 forewing veins. This immediately raises the possibility of misinterpretation, or that the type material of *leonora* was aberrant. Long ago Carcasson (1962) showed that the latter seems to be the case. In November 1959 the late Arthur Rydon collected three males and a female *leonora* in the Uluguru Mountains. Carcasson found that all four new specimens had the normal *Mylothris* venation, with ten veins reaching the forewing margin. He then asked T.G. Howarth at the Natural History Museum in London (BMNH) to re-examine the two *leonora* type specimens. Howarth reported that one was normal, with ten veins, but the other apparently lacked one of the radials. As all other characters of *leonora*, including male genitalia, were consistent with *Mylothris*, Carcasson had no hesitation in declaring *Pseudomylothris* a synonym of *Mylothris* (a conclusion with which we are entirely in agreement), and suggesting that Neustetter must have based his venation diagram on the aberrant individual (the paralectotype—see below). Carcasson's action was duly noted in the Zoological Record for 1962.

Our own examination of the aberrant individual suggests that rather than being entirely missing, veins R_1 and R_2 appear to run exceptionally close throughout their length, almost touching, and therefore appearing at modest magnifications like a single vein. Radial veins that run extremely close together have caused confusion in other butterflies (e.g. the genus *Bia* Hübner: Vane-Wright & Boppré, 2005)—and so it appears in this case, as both Neustetter and Talbot were misled.

MYLOTHRIS LEONORA KRÜGER, 1928, STAT. REV.

Mylothris leonora Krüger, 1928: 21. Lectotype female, TANZANIA: "D.-Ost-Afrika, Ukami" (BMNH), here designated. [Examined.]

Pseudomylothris leonora (Krüger); Neustetter, 1929: 191; Talbot, 1944: 184.

Mylothris leonora Krüger; Carcasson, 1962: 61–62; Carcasson, 1964: 142; Berger, 1980a: figs 7,8; Berger, 1980b: 872; Berger, 1985: 109, pl. 5 figs 3,4,6; Ackery *et al.*, 1995: 220; d'Abrera, 1997: 108, 109; Williams, 2010: 54.

Mylothris crawshayi leonora Krüger; D'Abrera, 1980: 94; Carcasson, 1981: 128; Kielland, 1990: 66, 269; de Jong & Congdon, 1993: appendix 8.2.

Mylothris leonora form *bondwa* Berger, 1985: 109, pl. 5 fig. 6. TANZANIA: "Bondwa (Mts Uluguru)".

Mylothris crawshayi: Collins *et al.*, 2007.

Mylothris leonora was described from two female specimens (syntypes), from Ukami, German East

Africa. Two female specimens (Figs 1–4) now in the Natural History Museum, London (BMNH), although they do not carry data labels that correspond precisely with the published description, have long been accepted as Krüger's original material. One of them, referred to by Talbot (1944: 184) as the "type" and by Carcasson (1962: 61) as the "holotype" (Figs 1, 2) bears the following labels: "Uluguru Berge O. Afr. / Myl. leonora Kr. Type ♀ / 18.28 [Joicey accession number] / Joicey Bequest Brit. Mus. 1934-120 / Type H.T. [attached by Joicey curator]" This specimen is hereby designated the lectotype of *Mylothris leonora* Krüger, 1928, and has been labelled accordingly.

The second specimen (Figs 3, 4), referred to by both Talbot (1944: 184) and Carcasson (1962: 61) as the "paratype", bears the following labels: "Uluguru Berge O. Afr. / Myl. leonora ♀ einzige Cotype / 31.28 [Joicey accession number] / 34/ Joicey Bequest Brit. Mus. 1934-120 / Type P.T. [attached by Joicey curator]" This specimen is hereby designated paralectotype of *Mylothris leonora* Krüger, 1928, and has been labelled accordingly.

M. leonora ♀ f. *bondwa* Berger differs from the typical female in having the hindwing suffused with orange, rather than plain, clear yellow. It seems possible that this butterfly exhibits female-limited polymorphism (class 7: Vane-Wright, 1975). However, both the lectotype and paralectotype of *leonora* have a distinctly orange cast to the hindwing (in contrast to the clear yellow of males), although this is not as extreme as in '*bondwa*'.

Distribution. Other than records given by de Jong & Congdon (1993; see below), *leonora* has only been recorded from the Uluguru Mountains, in the Morogoro district of Tanzania (Carcasson, 1992; Kielland, 1990). The only specific localities known to us are Ukami (Krüger, 1928), Lukwangule Plateau (Berger, 1980b) and Mount Bondwa (Berger, 1985). According to Kielland (1990), the butterfly occurs in montane forest and forest-grassland mosaic, at 1200–2640 m. Berger (1980b) records it from Lukwangule, South Ulugurus, at 2200–2500 m. Nothing is known about the early stages (Williams, 2010; see Braby, 2005b).

WHAT SPECIES-RANK STATUS SHOULD BE ACCEPTED FOR *MYLOTHRIS LEONORA* KRÜGER?

There are three main possibilities concerning the rank of *M. leonora*, all of which have been listed or supported by various authors since Krüger first proposed this taxon as a new species: a species restricted to the Ulugurus (endemic species hypothesis), a restricted subspecies of a more

widespread species-group taxon (endemic subspecies hypothesis), or a population of a more widespread species-group taxon (non-endemic hypothesis, including the possibility that *leonora* is a synonym of an earlier-established species or subspecies from elsewhere in Africa).

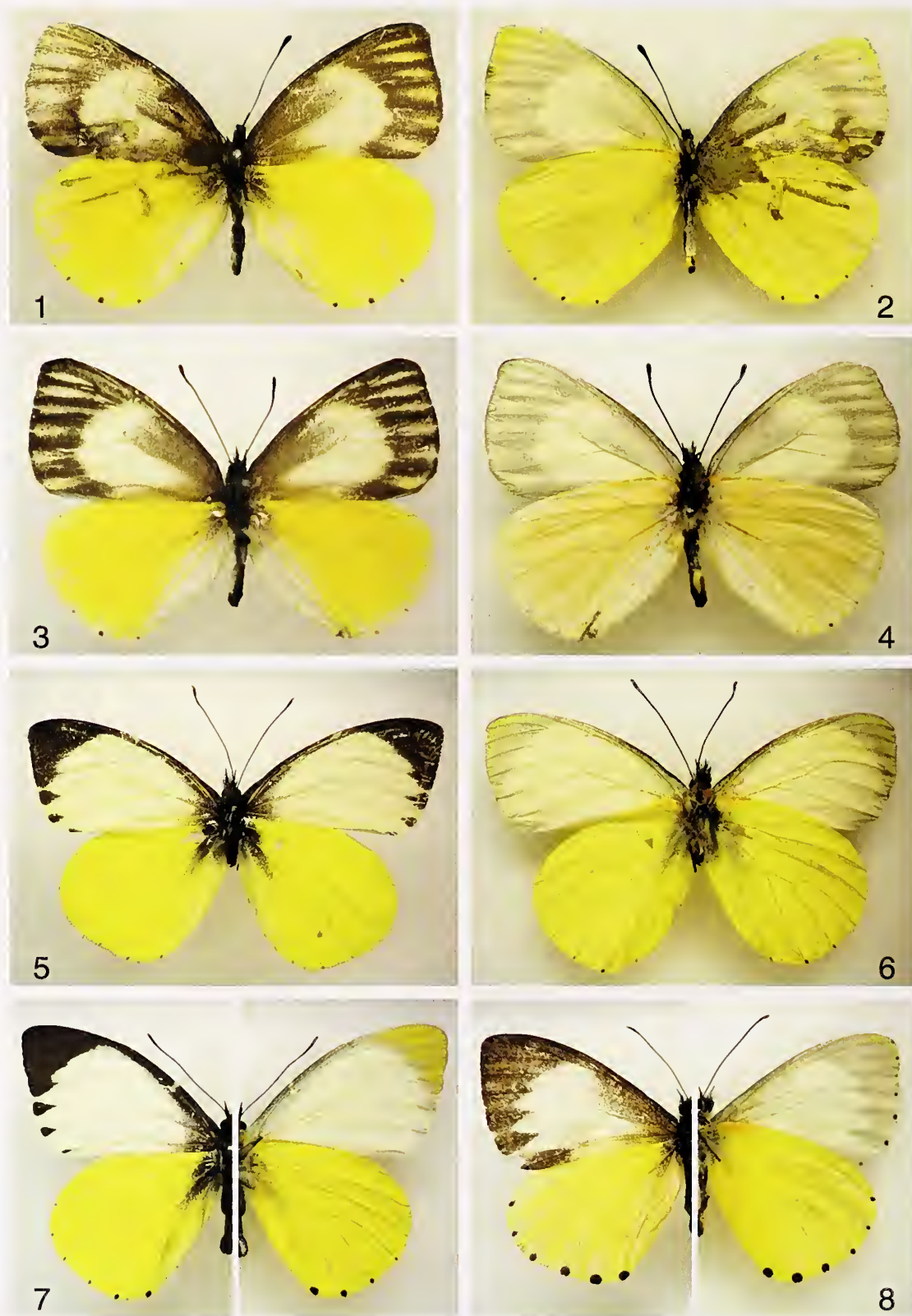
Endemic species hypothesis

This was clearly assumed by Talbot (1944), but more significantly it was accepted by Carcasson (1962) and Berger (1980b, 1985). One might also cite d'Abrera (1997) and Ackery *et al.* (1995) as further support for this hypothesis, but these works were based on various drafts of Carcasson's catalogue of Afrotropical butterflies (see Carcasson, 1981), and only differed where the authors had their own reasons to do so.

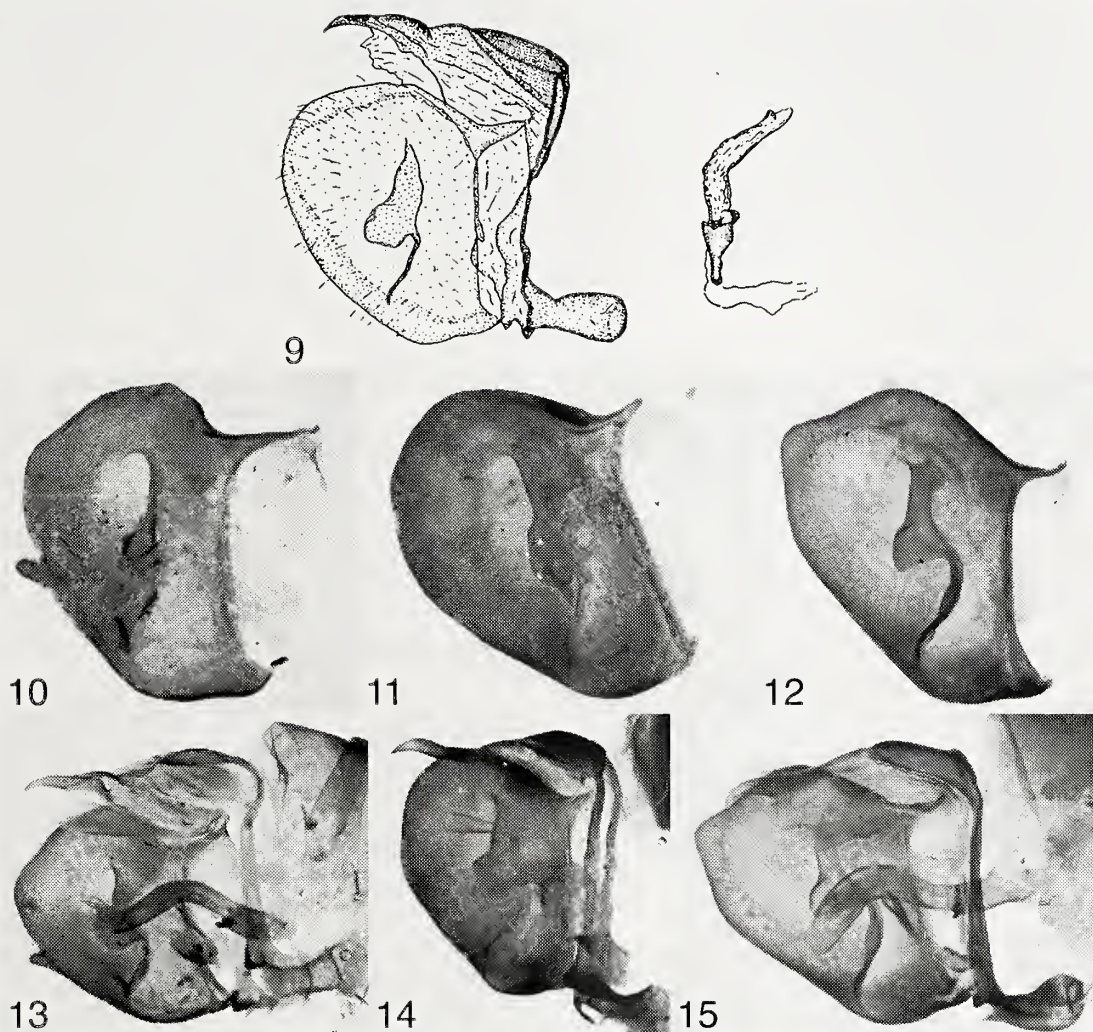
The most important account of the separate species hypothesis is given by Berger (1980b), who discussed three members of Talbot's (1944) *Mylothris sagala* Grose-Smith species-group found in the Ulugurus: *M. sagala seminigra* D'Abrera, September 1980 (= *M. sagala seminigra* Berger, December 1980, homonym, syn nov.), *M. leonora*, and *M. crawshayi bunduki* Berger, 1980. Berger noted that in these mountains he never encountered *M. sagala* outside the range 1400–1800 m, and that the single known specimen (holotype) of *crawshayi bunduki* was found at one of the *sagala seminigra* localities, Bunduki, at 1500 m. In contrast, *M. leonora* was only encountered in the more southerly Lukwangule Plateau, at 2200–2500 m. In addition to these apparent ecological differences between *crawshayi* and *leonora*, Berger (1980b, 1985) noted phenotypic differences in wing coloration pattern (both sexes), wing shape, and morphology of the genitalia (see discussion below).

Endemic subspecies hypothesis

Despite his earlier treatment, Carcasson (1981) placed *leonora* as the Uluguru subspecies of *Mylothris crawshayi* Butler, 1896, evidently believing he was the first person to make this change in status, marking his checklist entry "stat. nov." However, in print at least, he was anticipated by D'Abrera (1980). Neither author offered any explanation for the change in status (it is likely that D'Abrera was informed of Carcasson's intention through correspondence). Kielland (1990: 66) arrived at the same conclusion, perhaps independently: "I feel this taxon [*leonora*] is no more than a race of *crawshayi*. The only difference is in the female with the very wide and even marginal band, always interrupted by internervular white or pale-yellow streaks. Streaks are also present in the



Figures 1–8. *Mylothris* butterflies. 1–6, *M. leonora* Krüger: 1, 2, lectotype female ("Uluguru Berge"), upperside (1), underside (2); 3, 4, paralectotype female ("Uluguru Berge"), ups (3), uns (4); 5, 6, 'neallotype' male (Carcasson, 1962) ("Ulugurus, Nov. 1959, A.H.B. Rydon"), ups (5), uns (6). 7, 8, *M. crawshayi* Butler: 7, male, Malawi ("R. Crawshay, 96-156, Kasungu Mt., Nyika, 2.3.96"), ups/uns; 8, female syntype, Malawi ("R. Crawshay, 95-143, Nyankowa Mt., 6500 ft. alt., Apr. 9th [18]95"), ups/uns.



Figures 9–15. Male genitalia of *Mylothris* species (all specimens in BMNH). 9, *M. leonora*, 'neallotype' (Tanzania, Uluguru Mountains, A.H.B. Rydon; figures reproduced from Carcasson, 1962: fig. 17 (phallus inset), BMNH Rhopalocera Slide no. 3222). 10–12, right-hand valves, interior faces, reversed: 10, *M. crawshayi* (Malawi, Kantorongondo Mt., Nyika, 5900 ft, 15.iv.1895, R.W. [Crawshay], topotype, BMNH Rhopalocera Vial no. 8919); 11, *M. sagala* cf. *narcissus* Butler (Tanzania, Tanga, West Usambara Mts, Magamba Forest, 1800 m, 22.x.2001, S.D. Liseki, BMNH Rhopalocera Vial no. 8918); 12, *M. ruandana* Strand (Burundi, Kabira Forest, 7000 ft, i.1924, T.A. Barns, BMNH Rhopalocera Vial no. 8917). 13–15, terminalia, right-hand valves removed, phalluses *in situ* (all data as Figs 10–12): 13, *M. crawshayi*; 14, *M. sagala* cf. *narcissus*, 15, *M. ruandana*.

population from Nguru Mts. and in some specimens in the U[d]zungwa Range, but with much more dentate inner-side of the marginal band. I cannot detect differences in the genitalia of *leonora* and *crawshayi*."

With respect to the male genitalia, Carcasson (1962) compared *Mylothris leonora* with *M. sagala* (of which, no doubt following Talbot, 1944, he considered *M. crawshayi* to be a subspecies, or even only a form), noting that, in comparison, the uncus of *leonora* was more pointed, its valve less rounded, and the harpe more irregular. His illustration (Carcasson, 1962: fig. 17) is reproduced here as Fig. 9. In describing the

new species *M. kiellandi*, Berger (1985) stated that its genitalia differed from *M. crawshayi* in having a small apophysis on the dorsal margin of the valve longer and finer than that seen in *crawshayi*, and also had a more trapezoidal-shaped harpe. Berger (1985) also stated that *M. leonora* completely lacked the dorsal apophysis, commenting that Carcasson's (1962) figure was "exact." These statements cannot be reconciled with Kielland's comment that the genitalia of *leonora* and *crawshayi* are indistinguishable (see discussion, below).

Despite noting some similarities between true *leonora* females and females of *crawshayi* from the

Ngurus and Udzungwas, Kielland (*loc. cit.*) was quite clear that in his view subspecies *leonora* was confined to the Ulugurus, while the nominate race of *crawshayi* occurred in the Nguru, Ukaguru and Udzungwa ranges and Mt Image in south-eastern Tanzania, as well as adjacent Nyika Plateau of northern Zambia (Heath *et al.*, 2002) and northern Malawi (Gifford, 1965, as a form of *sagala*).

Non-endemic hypothesis

This is the position adopted by de Jong & Congdon (1993), who listed *Mylothris crawshayi leonora* as a subspecies from the Nguru, Uluguru, Ukaguru, Rubeho and Udzungwa mountains, with nominate *Mylothris crawshayi crawshayi* restricted to the Nyika Plateau in northern Malawi (the type locality) and eastern Zambia. No argument is offered in support of this interpretation, but it is equivalent to synonymising *M. crawshayi bunduki* Berger, *sensu* Ackery *et al.* (1995) and Williams (2010) (who regarded all Tanzanian populations of *M. crawshayi* as attributable to subspecies *bunduki*), with *M. leonora*.

DISCUSSION OF THE ALTERNATIVE HYPOTHESES

Wing shape and pattern characters

The taxa *Mylothris crawshayi*, *M. leonora* and *M. kiellandi* appear similar, and are plausibly closely related (Kielland, 1990). Phenotypically, *M. leonora* differs from typical *M. crawshayi* in the shape of the outer marginal dark forewing border of the female. This border is broader in *leonora* (about 6–7 mm instead of ca 5 mm in most *crawshayi*), with an irregular but not clearly dentate proximal margin, enclosing five or six, usually very distinct pale streaks (Figs 1 & 3, cf. Fig. 8). As observed by Kielland, some

females from the Nguru and Udzungwa Mts that he included in (subspecies) *crawshayi* do have pale streaks, but these are less clear, and the proximal margin of the band, even when widened in some individuals, is always dentate (Kielland, 1990: pl. 13).

Despite some variation, as proposed by Berger (1980b, 1985), within an extended *Mylothris sagala*-group (see below), three diagnosable taxa supposedly related to *crawshayi* can be separated on colour pattern and wing shape characters, according to the key below.

Female *M. leonora*, as characterised above, are readily diagnosable, although the males hardly differ in colour pattern from typical *M. crawshayi* except with respect to the colour of the forewing apex beneath. However, were we to accept the arrangement of de Jong & Congdon (1993), on available characters, the various populations of '*M. crawshayi leonora*' would be phenotypically heterogeneous.

Male genitalia characters

Talbot (1944) noted that characters of the male genitalia, notably the form of the harpe and the presence or absence of an apical projection (distal projection of Klots, 1933: 226) to the valve, offer useful characters at species and species-group levels. He divided the genus into four very unequal species groups, all the species of interest here supposedly belonging to the *sagala* group (but see observations below on *M. crawshayi*).

With respect to the male genitalia of the *sagala* group, Talbot (1944: 163) stated: "Valve without any apical projection . . . Harpe very broad, short and rounded, similar to that of [*trimenia*] (see Talbot, 1946) and unlike that of other groups." Within the *sagala* group Talbot included only two species, *sagala* (Fig. 11) and *ruandana* Strand (Fig. 12). However, to this must now be added *M. carcassoni* van Son, 1948, from

Key for separation of *Mylothris crawshayi*, *M. leonora* and *M. kiellandi*.

1. Posterior section of male upperside forewing outer margin lacking a complete dark border continuous with the black forewing apex, the tips of veins Cu₁, Cu₂ and 1A being marked only with separate black chevrons (Figs 5, 7); sexually dimorphic species.....2
- Male upperside with a continuous, solid black border along entire forewing outer margin, about 6 mm in width, from apex to termen; inner margin of this border more or less distinctly dentate but occasionally not so (Berger, 1985: fig. 5); males and females similar in colour pattern (West Usambara Mts).....*M. kiellandi* Berger, 1985
2. Underside male forewing almost entirely white, only obscurely yellowed at apex; female with broad dark border running along the entire forewing outer margin, about 6 mm in width, always with at least five but usually six pale longitudinal streaks, with inner margin of the border, although irregular, not distinctly dentate; outer margin of female forewing (and to some extent male) slightly but distinctly sinusoidal, not straight or evenly rounded (Uluguru Mts) (Figs 1–6).....*M. leonora* Krüger, 1928
- Underside male forewing mostly white but with clear yellow apex; female forewing with slightly narrower dark border, about 5 mm in width, occasionally marked with more or less distinct longitudinal streaks but normally all dark, with the posterior section of the inner margin of the border normally distinctly dentate (but not so in type specimen of *M. crawshayi* female form *iringa* Berger, 1985); border element at tip of vein 1A often detached; outer margin of female forewing usually straight and then evenly rounded towards the apex, only rarely slightly sinusoidal (from Nguru Mts southwest through Udzungwa Mts to north-eastern Zambia and northern Malawi) (Figs 7, 8).....*M. crawshayi* Butler, 1896

the border area between Mozambique and Zimbabwe, which also completely lacks an apical projection (van Son, 1948), and the South African endemic *M. trimenia* Butler, 1869, which Talbot excluded due to a muddle over genitalia dissections (Talbot, 1946). In making this confusion explicit, van Son (1949: 228, figs 124, 126) even suggested that *trimenia* and *sagala* might be conspecific. Further, Talbot placed *crawshayi* within *sagala* as merely a form of *M. sagala dentatus* Butler, 1896, but all more recent authors have treated *crawshayi* as a separate species (*dentatus* does belong to *sagala*). Part of the earlier confusion may also be due to Aurivillius (1910: pl. 11d), who illustrated what is clearly a form of the very variable *M. sagala* misidentified as *M. crawshayi*. As shown below, true *M. crawshayi* is abundantly distinct, and probably does not even belong to the *sagala* group *sensu stricto*.

As already noted, Berger (1980b) discussed *M. leonora* as a member of the *sagala* group, to which it conforms based on the male genitalia (Fig. 9, cf. Figs. 11, 14). With respect to *M. kiellandi*, Berger (1985) described his new species as close to *M. leonora* and *M. crawshayi*. In particular, he compared the male genitalia of *M. kiellandi* with *M. crawshayi*, stating that the valve of *kiellandi* carries a small “dorsal [*sic*] apophyse” that is longer and finer than that of *crawshayi*. We do not have access to material of *kiellandi* that we can dissect, nor have we found any published diagram for this species. Kielland (1990) states only that it is closest to *crawshayi*. How are we to interpret “dorsal apophyse” – is this the apical (or distal) projection (apophysis), or was he referring to the dorsal articulating connection of the valve to the vinculum? If the former, which seems more likely, this would suggest that, based on a typological approach to the characters of the male genitalia, that neither *kiellandi* nor *crawshayi* belong to the *sagala* group.

We have been able to confirm this for nominate *crawshayi* (Fig. 10, 13). The preparation, made from original but non-type material collected by Richard Crawshay from one of the two original type localities in Malawi, shows that the valve of *crawshayi* has a well-developed apical projection, unlike *M. sagala* or *M. leonora*. Moreover, the valve has a very different overall shape and harpe. We can confirm that, by microscope examination but without dissection, all the male type specimens of *M. crawshayi* have the apical projection, which is easily and clearly seen in posterior view.

From this we can conclude that *M. crawshayi* and *M. leonora* are entirely separate, possibly not even belonging to the same species group. If so, then the similarity in colour pattern between the two would seem remarkable and unexplained. Alternatively, the characters of the male genitalia are specific, and

offer little or no information regarding ‘higher’ taxa, such as the species groups proposed by Talbot. On present evidence, if we regard the absence of an apical projection (when coupled with a more or less rounded valve outline) as a loss-apomorphy (the vast majority of *Mylothris* species have an apical projection: Talbot, 1944: figs 1–26), then *M. leonora* plausibly belongs to a small monophyletic group that includes *M. sagala*, *M. carcassoni*, *M. trimenia*, and possibly *M. ruandana* (Figs. 12, 15), but excludes *M. crawshayi* and, it would seem, *M. kiellandi* – but this reformulated *sagala* group might nonetheless be nested within a slightly larger group including *M. crawshayi*. Then the similarities in colour pattern might simply be plesiomorphous. Molecular data would surely be the most rapid and effective way to confirm or refute such suggestions.

We are left with a puzzle, however. What was Jan Kielland comparing when he stated “I cannot detect differences in the genitalia of *leonora* and *crawshayi*” (Kielland, 1990: 66)? The differences between the two (Figs 9, 10) are very clear. Kielland would surely have been comparing *leonora* from the Ulugurus with what he considered to be *crawshayi* from elsewhere in Tanzania, not from Malawi. Is it possible that other, perhaps all Tanzanian populations previously attributed to *crawshayi* are in fact *leonora*? In other words, *M. leonora* is not endemic to the Ulugurus, but is a more widespread Tanzanian endemic. This would be equivalent to the “non-endemic hypothesis” of de Jong & Congdon (1993), but with the Malawi (Nyika) and Tanzanian “subspecies” raised to wholly separate species status.

In this context the original material of *M. crawshayi bunduki* becomes very significant. This taxon was based on a single male supposedly collected at Bunduki, Uluguru Mountains, in December 1913 (Berger, 1980b: 874). Berger collected in the same area during May–August 1971, but did not encounter this butterfly. It would be very desirable to confirm or refute this old record, as the presence of true *crawshayi* in the Ulugurus (although in a different biotope to *M. leonora*) would be of considerable importance in further confirming their separate status. Kielland (1990) made no mention of *crawshayi bunduki*, or its supposed presence in the Ulugurus. Unfortunately, extensive efforts to trace the holotype of *bunduki* in the Musée Royal de l’Afrique Centrale (Tervuren) have not met with success. Were the holotype of *bunduki* be found to have *leonora*-like genitalia, and this also applied to other Tanzanian material currently regarded as *M. crawshayi*, then it would seem that *M. leonora* could no longer be regarded as a species narrowly endemic to the Uluguru Mountains. If on the other hand all such specimens were found to have *crawshayi*-like male genitalia, then this would confirm

M. leonora as a narrow endemic. Unfortunately, we currently do not have access to any such material, so this must wait for the future.

In conclusion, *M. crawshayi* sensu stricto and *M. leonora* cannot be regarded as the same species, as clearly pointed out by Berger (1980a,b; 1985). They should continue to be regarded as separate, as listed by Ackery *et al.* (1995), d'Abrera (1997) and Williams (2010). What remains uncertain is the identity of the Tanzanian *Mylothris* populations from the Nguru, Ukaguru, Image and Udzungwa mountains attributed by Kielland (1990) to *M. crawshayi*. Are these also *M. leonora*? It may be significant that of these populations Kielland (1990: 66) states "flight very rapid for a *Mylothris*", the very same point made by Berger (1980b: 873, 874) concerning *M. leonora* while, at the same time, pointing to Richard Crawshay's original observation, noted by Butler (1896), that the flight of *crawshayi* is "weak". Even so, however attractive this hypothesis may seem to explain Kielland's otherwise paradoxical statement about the genitalia being inseparable, Berger (who examined the genitalia of these insects) was equally emphatic that two separate, *crawshayi*-like species occur in Tanzania. More work is needed, both morphological and molecular.

EENDEMISM OF ULUGURU BUTTERFLIES

Hansen (2005: 54) states that butterfly endemism in the Uluguru Mountains is 27%. This would be remarkable, but seems to reflect a misrepresentation of the data, or a misreading of de Jong & Congdon (1993). Congdon & Bampton (2001) list seven species strictly endemic to the Ulugurus. Collins *et al.* (2007) note a total of 349 butterfly species from the whole mountain block. Among these the following eight appear strictly endemic at species level: *Celaenorrhinus kimboza* Evans (Hesperiidae), *Celaenorrhinus uluguru* Kielland (Hesperiidae), *Chondrolepis* sp. nov. Larsen & Congdon MS (Hesperiidae), *Anthene montana* Kielland (Lycaenidae), *Baliochila citrina* Henning & Henning (Lycaenidae), *Harpendyreus bergeri* Stempffer (Lycaenidae), *Uranothauma lukwangule* Kielland (Lycaenidae), and *Uranothauma uganda* Kielland (Lycaenidae). Two species listed as endemic by de Jong & Congdon (1993) not included here are *Charaxes mccleryi* van Someren (Nymphalidae) and *Pseudathyma uluguru* Kielland (Nymphalidae), both of which have now been recorded (at species level) beyond the Ulugurus (Collins *et al.*, 2007).

If only the eight strict endemics listed above are counted, butterfly endemism in the Ulugurus, measured as a percentage of the total Uluguru butterfly fauna, is 2.3% ($8/349 \times 100$). This rises

modestly to 2.6% if *Mylothris leonora* is recognised as a separate species, as we argue here that it should be—one of the 134 species of butterflies listed as endemic to Tanzania as a whole (Williams, 2010). As a separate species, *M. leonora* thus offers further support for the irreplaceable nature of the Uluguru Mountains—but it certainly does not represent a higher taxon, and might only prove eventually to be the nominate subspecies of a more widespread Tanzanian endemic. However, this must be assessed in the context that no higher taxon of vertebrates or butterflies is restricted to the Uluguru conservation area.

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EDITOR'S NOTE

Paper copies of this article will be deposited in the following libraries: Academia Sinica, Taipei, Taiwan; CSIRO, Australia; Humboldt-Museum, Berlin, Germany; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA; Museum of Natural History, Paris, France; Museum of Zoology, University of Sao Paulo, Brazil; Natural History Museum, London, UK; Senckenberg-Museum, Frankfurt, Germany; Smithsonian Institution, NMNH Library, Washington D.C. USA.

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